Autograft reconstructions for bone defects in primary total knee replacement in severe varus knees

Yatinder Kharbanda, Mrinal Sharma

Abstract

Background: Large posteromedial defects encountered in severe varus knees during primary total knee arthroplasty can be treated by cementoplasty, structural bone grafts or metallic wedges. The option is selected depending upon the size of the defect. We studied the outcome of autograft (structural and impaction bone grafting) reconstruction of medial tibial bone defects encountered during primary total knee replacement in severe varus knees.

Materials and Methods: Out of 675 primary varus knees operated, bone defects in proximal tibia were encountered in 54 knees. Posteromedial defects involving 25-40% of the tibial condyle cut surface and measuring more than 5 mm in depth were grafted using a structural graft obtained from cut distal femur or proximal tibia in 48 knees. For larger, peripheral uncontained vertical defects in six cases, measuring >25 mm in depth and involving >40% cut surface of proximal tibial condyle, impaction bone grafting with a mesh support was used.

Results: Bone grafts incorporated in 54 knees in 6 months. There was no graft collapse or stress fractures, loosening or nonunion. The average followup period was 7.8 years (range 5-10 years). We observed an average postoperative increase in the Knee Society Score from 40 to 90 points. There was improvement in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores in terms of pain, stiffness and physical function during activities of daily living.

Conclusion: Bone grafting for defects in primary total knee is justified as it is biological, available then and is cost effective besides preserving bone stock for future revisions. Structural grafts should be used in defects >5 mm deep and involving 25-40% of the cut proximal tibial condyle surface. For larger peripheral vertical defects, impaction bone grafting contained in a mesh should be done.

Key words: Osteoarthritis knee, autografting, bone defects, primary total knee replacement, severe varus deformity

Introduction

Large posteromedial asymmetrical osseous defects are often seen in proximal tibia while performing a primary total knee arthroplasty (TKA) in severe varus knees. Majority of these are peripheral uncontained defects. Depending upon the size of the defect, these can be treated with cementoplasty, cement with screw augmentation or metal wedges that constitute an integral part of modern knee systems.[1-3] The use of autografts is a viable alternative for the treatment of massive bone loss.[4] To achieve axial implantation of the prosthesis and stable fixation of the components, we performed osseous reconstruction of the medial tibial condyle defect using autologous bone grafts obtained from the cut proximal tibia or distal femur. Our aim was to obtain firm seating of the tibial tray on a rim of viable bone, along with rigid press fixation of the medullary stem. This study highlights the outcome of autograft reconstruction for the management of proximal tibial defects in osteoarthritic knees with a severe varus deformity at a minimum of 5 years followup.

Department of Orthopedics, Indraprastha Apollo Hospital, New Delhi, India

Address for correspondence: Dr. Mrinal Sharma,
House No 804, Bluestone 1, Supertek Emerald Court,
Sec 93 A Noida, Uttar Pradesh, India.
E-mail: dr.mrinalsharma@gmail.com

Materials and Methods

This was a retrospective analysis of the outcome of bone grafting for severe varus knees (>15° central axis). Out of 675 primary total knee replacements (TKRs) performed at our center between 2002 and 2007, 54 knees in 34 patients with severe varus needed bone grafting to achieve stable axial implantation of the prosthesis. Clearance from the internal review board was taken. Only those patients with severe varus, osteoarthritis and defects >5 mm in the cut proximal tibia condyle were included. Valgus knees, rheumatoid knees and knees with defects <5 mm were

excluded. All 34 patients (age range 55-78 years) had advanced osteoarthritis. Twenty two of them were females and 12 were males. All had body mass index between 20 kg/m^2 and 40 kg/m^2. The mean varus alignment was 28° (range 22°-38°). All the patients were operated by the same team. Informed consent was taken from all the patients.

Operative procedure

Intraoperatively the defects were measured after the proximal tibial cut was taken. A conservative tibial cut was always taken (8 mm from the lateral tibial plateau). Defect dimensions of length, width and depth were measured using a millimeter scale. The width of the proximal (cut) tibia was also measured. The ratio of defect to proximal tibial cut surface was measured. Posteromedial defects involving 25-40% of the tibial condyle cut surface and measuring more than 5 mm in depth (range 5-25 mm) were bone grafted using structural grafts [Figures 1-3].[4] Structural bone grafts were used in 48 knees and autogenous impaction bone grafting contained with a wire mesh was done in six patients. The defect was fashioned using a saw. The base of the defect was made raw by drilling with a 2.5 mm drill bit. Cartilage was removed from the bone cuts. Structural bone grafts originating from proximal tibial cut or distal femur cut were fixed with screws by using a technique described by Windsor *et al.* [Figure 2d].[4] For peripheral vertical oriented bone defects of larger magnitude (>25 mm

depth and involving 40% of the cut surface of tibia condyle) morselized autograft supported by mesh and fixed with screws was used [Figure 4]. The peripheral defect was contained by a V-shaped stainless steel mesh which was fixed with cortical screws (two superiorly and one at the base). Morselized grafts (size 5-7 mm) prepared from bone obtained from bony cuts were then impacted and tibial plate was cemented on top. Stem extenders were used in all cases except in two of our earlier cases [Figure 3b,c].

Followup Static quadriceps strengthening exercises were started in the immediate postoperative period. Gentle range of motion exercises were started the next day. All patients were mobilized with full weight bearing with the support of a walker on the second day. Postoperative radiographs were taken on the second day. All patients were followed with radiographs at 2 weeks, 6 weeks, 3 months, 6 months, 1 year and then yearly. Knee society scores and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores were recorded pre and postoperatively.[5,6]

RESULTS

The average followup was 7.8 years (range 5-10 years). No patients were lost to followup. All the patients had complete incorporation of the grafts (structural and impaction) in average 4.5 months (range 3-6 months). There were no
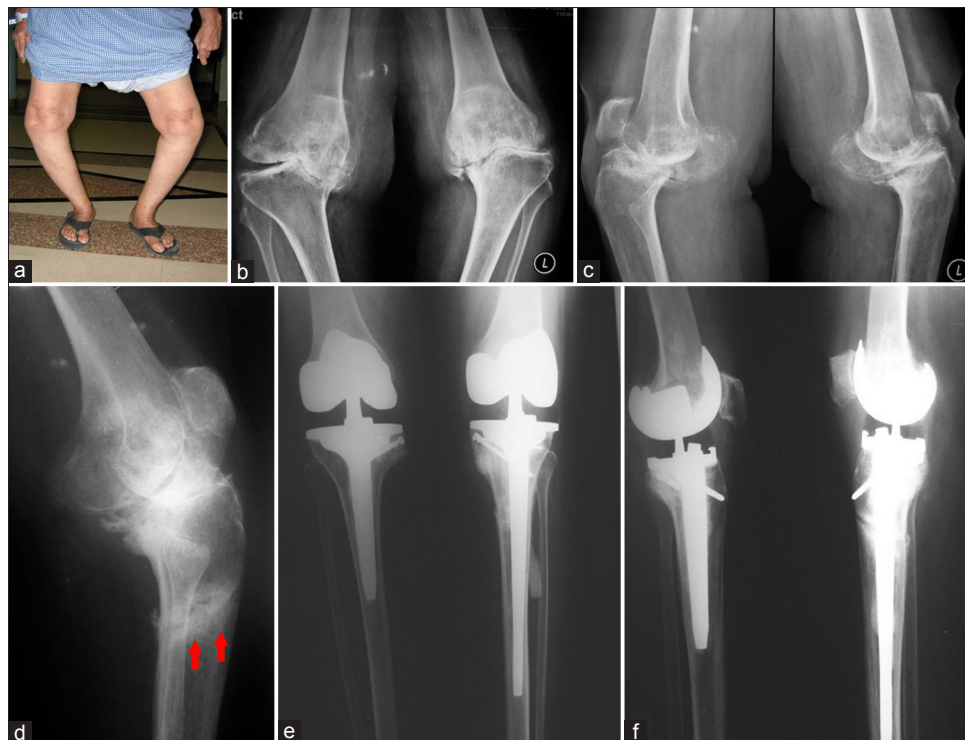

Figure 1: (a) Clinical preoperative photograph of a patient with severe varus knees. (b) Preoperative anteroposterior (AP) weight-bearing view of the knee showing the medial bone defect. (c) Lateral view of knees showing severe degenerative changes (d) Lateral view of left knee showing a stress fracture that developed preoperatively (arrow mark) (e) AP X-ray of the knee at 5 years followup showing complete incorporation of structural graft fixed with screw and no collapse. (f) Lateral views of knee showing the long stem extenders used to bypass the stress fracture
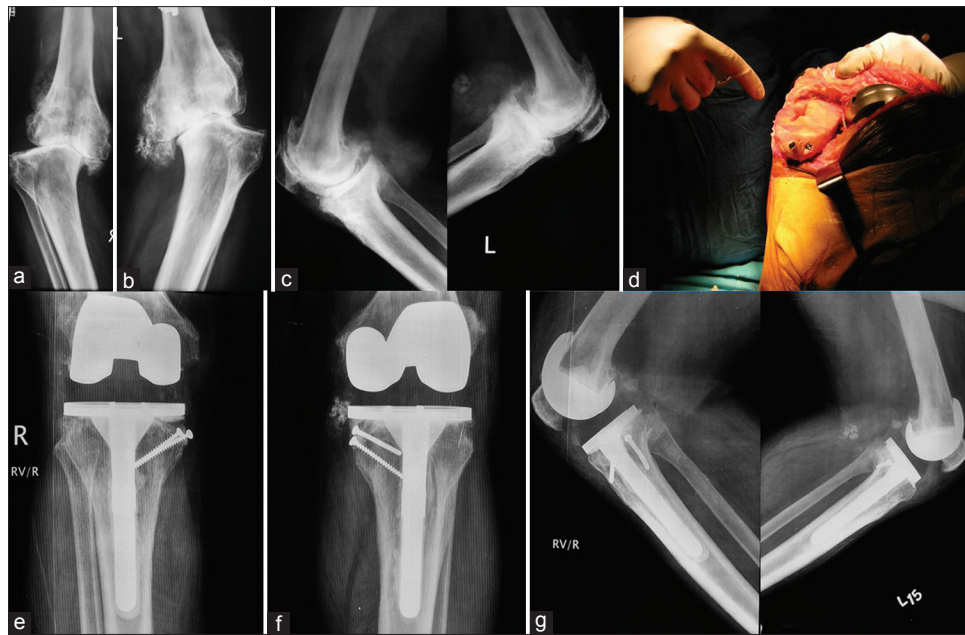
Figure 2: (a and b) Anteroposterior radiographs of both knees showing the bone defect and subluxation. (c) Lateral radiographs of both knees showing severe degerative changes (d) Use of structural bone graft for filling the defect using the technique described by Windsor *et al*. Postoperative radiographs anterposterior (e,f) and lateral (g) views showing incorporated structural autograft in anteroposterior and lateral views
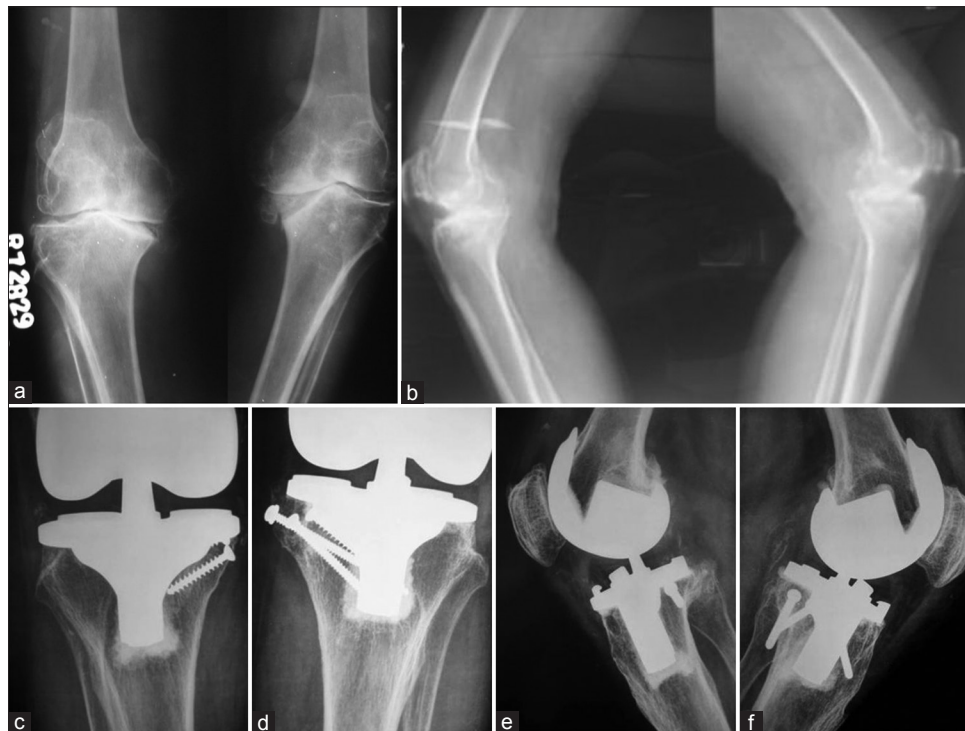

Figure 3: (a) Standing anteroposterior radiographs of both knees with severe varus and tibial bone defects. (b) Preoperative lateral views of knee joints showing degenerative changes. (c and d) Postoperative anteroposterior radiographs showing complete incorporation of bone graft fixed with screws. No stem extenders were used in this case and (e and f) Lateral radiographs of knees showing complete incorporation of bone graft and implant *in situ*

late (>6 months) failures due to graft absorption. Even in two of our earlier cases in which no tibial stem extender was used, complete graft incorporation was seen. Nonunion of the graft, collapse, stress fractures or loosening was not seen in any of the cases. Morselized bone graft incorporated

early in around 3 months [Figure 4e,f]. Loosening of the screws used to fix the structural graft was not seen secondary to battery effect. (It occurs when two alloys of different metals touch each other and an electrochemical reaction starts. This leads to dissolution of metals and
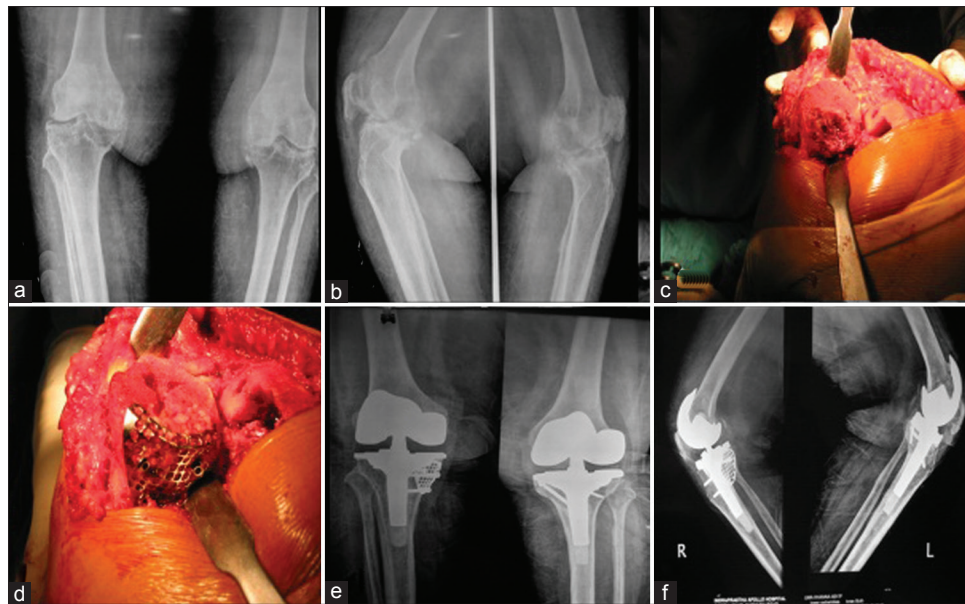
Figure 4: (a and b) Anteroposterior and lateral radiographs of the knee showing the right knee has a deeper, vertical and peripheral uncontained defect. (c) Intraoperative picture showing the peripheral bone defect that involves more than 40% of tibial plateau and measures 3 cm in depth. (d) Containment of defect with stainless steel wire mesh and screws, followed by impaction autografting to reconstruct the proximal tibial defect. (e and f) AP and lateral views of the knee joint at 4.5 years followup showing complete graft incorporation. Impaction bone graft was done on the right for larger defect and structural bone graft was done on the left side

corrosion). Implant loosening was not seen. One patient reported pain on the medial side of the joint and proximal tibia, probably secondary to pes anserinus bursitis due to irritation by the mesh used to support the morselized graft. We observed an average postoperative increase in the Knee Society Score from 40 (28-52) to 90 (85-93) points. There was improvement in WOMAC scores from an average of 72 (range 50-93) to 43.9 (range 27.3-50) in terms of pain, stiffness and function during activities of daily living. The postoperative alignment was measured and ranged from 0° to 1° varus. The average range of motion achieved was 2° (0°-5°) extension and 128° (115°-135°) flexion.

DISCUSSION

Large posteromedial bone defects are commonly encountered in proximal tibia while performing a primary TKR. Removing bone to the level of the defect is not recommended as the computed tomography (CT) scans have shown that >1 cm below the joint line, the quality and quantity of the supporting cancellous bone diminishes. Equally important, the attachments of iliotibial band, pes anserinus, patellar ligament and Posterior cruciate ligamant can be compromised.[7] Problem of asymmetrical bone loss can be addressed using cementoplasty, cement with screws, bone grafting, custom implants or metal wedges.[1-4] Reinforcement of the proximal tibia with autogenic bone grafts preserves an area of subchondral bone essential for optimal thickness of the cement and fixation of the implants. Bone grafts reduce the need for custom implants

and prevent implant failure. Autologous bone grafts can be successfully used for reconstruction of large osseous defects. They are available and are biological and cost effective. Our goal was to reconstruct the defect with host bone (structural or impaction depending upon the size of the defect), which was followed by primary TKR. There are many reports in literature on bone grafting for defects in primary TKA. Our study is a retrospective analysis of the management of bone defects and outcome after structural and impaction autografting in primary TKA in Indian patients with severe varus knees. Moreover, impaction bone grafting has rarely been used as a treatment for bone defects in primary knees.

Dorr described a few prerequisites for complete graft incorporation. He advocated the following: (1) surface preparation of host bone to expose a viable bony bed (2) definition of the defect and preparation of the graft so that excellent fit and fixation are obtained (3) coverage of the graft by the component to prevent resorption of unstressed graft which may compromise the press fit of the graft and lead to failure by collapse (4) protection of the graft from overload by correct alignment of the components and limb and by limited weight bearing until union occurs and (5) protection of the graft by use of a stemmed component when indicated.[8] Dorr *et al.,* used bone grafts in 24 primary or revision knees. Twenty two of these grafts incorporated. They reported nonunion in two grafts which was followed by collapse in one. They recommended bone graft for a tibial defect involving 50% or more of the bony support of either tibial plateau or whenever a

cement column under the prosthesis would measure more than 5 mm in height.[9] Laskin performed bone grafting in 26 patients with severe tibial bone loss and varus/valgus instability. He reported dissolution of four grafts within the first year with implant subsidence. Four grafts failed to incorporate. He reported an overall success rate of 67% at 5 years. He recommended prosthetic shims or wedges in large fragment defects, but to continue to use bone grafting for smaller, circumscribed defects.[10] We have had a good outcome using bone grafts, without any graft collapse even in severe, large >50% defects of posteromedial tibia.

Parks and Engh[11] showed promising clinical results of bone grafts in TKR after evaluating the histopathology of nine bone grafts (autograft and allograft) used in primary TKR. All allografts were intact, but did not revascularize. The autografts were viable bone. New bone was being laid down on the dead graft bone at the periphery of the allografts. No change in the bone to cement interface, no graft collapse, no development of radiolucent lines and no component loosening occurred in these cases.[11] The authors prefer the use of autograft compared to allograft in primary TKR. Liu et al. operated 50 knees with medial tibial bone grafts fixed with screws and compared the results with those of a control group of normal TKRs and found no difference. One graft resorbed in their series and three patients had split fractures in the sclerotic medial tibial condyle.[12] Pei et al. operated 19 knees with severe genu varum and bone defects treated with TKR and step cut bone graft for medial defects. No fixation was used for the graft. Long tibial stem extenders were used in three patients. The postoperative knee society scores improved significantly and there were no graft failures even at an average followup of 25 months.[13]

Gaweda et al.[14] compared the results of TKR with bone grafting in 37 knees with 37 normal TKRs without the use of bone graft. Autologous solid bone grafting was used in 22 knees, morselized graft was used in 13 knees and 2 knees required both types of grafts. Bone grafts (both solid and morselized) healed in 21 knees. In four knees, progressive bone graft lysis was observed. The remaining knees showed lack of evidence of graft incorporation. The authors reported no difference in the long term followup results of both the groups. We also found no difference in the long term results after structural or impaction bone grafting, except for early incorporation of the morselized graft.[14] Watanabe et al. performed autologous bone grafting in 30 TKRs without using screws and showed union in all cases.[15] We recommend the use of at least two screws for initial stability of the graft and to achieve compression at the graft host bone interface. Rawlinson et al., in their cadaveric study, concluded that the use of stem extenders improves knee stability by reducing bone stresses and micromotion between the implant and the adjacent bone.[16] We also recommend and prefer to use stem extenders in all our cases. Similar results with the use of structural bone grafts in primary TKR have been shown by other authors such as Scuderi et al., Aglietti et al. (14 cases with 4-year followup), Pierzchala and Kusz (8 patients), Altchek et al. (14 patients) and Keska et al. (8 knees).[16-21]

Cai et al. had used the pulverized (5-8 mm) impacted bone graft to repair the bone defect of tibial plateau in TKA in 74 knees with varus or valgus and had shown encouraging results.[22] We also used impaction bone grafting supported by mesh in six knees. The results have been encouraging with early incorporation of the graft in all cases. There was no late collapse or implant loosening. One case had pes anserinus bursitis, probably secondary to irritation by the mesh. This settled after few weeks of conservative treatment. The use of wire mesh in primary TKA is akin to that used for revision knee arthroplasty.[23] Our study has some limitations. First, the number of patients in the study was small Second, the size of the defects could not be accurately measured as all defects were of variable sizes and shapes and no device was available to measure their volume intraoperatively. We tried to calculate and quantify the defects as a percentage of the cut proximal tibia and depth in millimeters. Unfortunately no guidelines are available in literature regarding reconstruction options based on volumetric loss. We had not done CT scans to measure volumetric loss. It would always be better to define defects as volume rather than as depth and percentage of tibial surface. Better definition of defect guides the management-structural, impaction or use of cones/metaphyseal sleeves and revision instrumentation. Finally, except for the radiographic incorporation of grafts, there is no histological proof of graft incorporation in our study.

To conclude, bone grafting for defects in primary TKR is justified as it is biological, available then and there, cost effective and has shown excellent results. It also provides bone stock for future revision surgeries. Structural bone grafts should be used in defects involving 25-40% of the cut surface of tibia condyle and measuring 5 mm in depth. Impaction bone grafting is advisable in peripheral vertical oriented defect involving >40% of the cut tibial condyle surface and measuring >25 mm in depth.

REFERENCES

1. Lotke PA, Wong RY, Ecker ML. The use of methylmethacrylate in primary total knee replacements with large tibial defects. Clin Orthop Relat Res 1991;270:288-94.
2. Ritter MA, Harty LD. Medial screws and cement: A possible mechanical augmentation in total knee arthroplasty. J Arthroplasty 2004;19:587-9.
3. Pagnano MW, Trousdale RT, Rand JA. Tibial wedge augmentation for bone deficiency in total knee arthroplasty. A followup study. Clin Orthop Relat Res 1995;321:151-5.

4. Windsor RE, Insall JN, Sculco TP. Bone grafting of tibial defects in primary and revision total knee arthroplasty. Clin Orthop Relat Res 1986;205:132-7.

5. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinicalrating system. Clin Orthop Relat Res 1989;248:13-4.

6. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)-development of a self-administered outcome measure. J Orthop Sports Phys Ther1998;28:88-96.

7. Wheeless textbook of orthopedics. www.wheelesonline.com.

8. Dorr LD. Bone grafts for bone loss with total knee replacement. Orthop Clin North Am 1989;20:179-87.

9. Dorr LD, Ranawat CS, Sculco TA, McKaskill B. Bone graft for tibial defects in total knee arthroplasty 1986. Clin Orthop Relat Res 2006;446:4-9.

10. Laskin RS. Total knee arthroplasty in the presence of large bony defects of the tibia and marked knee instability. Clin Orthop Relat Res 1989;248:66-70.

11. Parks NL, Engh GA. The Ranawat Award. Histology of nine structural bone grafts used in total knee arthroplasty. Clin Orthop Relat Res 1997;345:17-23.

12. Liu J, Sun ZH, Tian MQ, Wang P, Wang L. Autologous bone grafting plus screw fixation for medial tibial defects in total knee arthroplasty. Zhonghua Yi Xue Za Zhi 2011;91:2046-50.

13. Pei Z, Guan ZP, Zhang SL, Li YP, Zhang Z. Autogeneous bone graft in the treatment of total knee arthroplasty for severe genu varus with tibial plateau bone defect. Beijing Da Xue Xue Bao 2011;43:707-13.

14. Gaweda K, Tarczyńska M, Gagala J. The results of primary total knee arthroplasty with bone stock restoration by autologous grafts from resected bony ends. Chir Narzadow Ruchu Ortop Pol 2006;71:423-6.

15. Watanabe W, Sato K, Itoi E. Autologous bone grafting without screw fixation for tibial defects in total knee arthroplasty.

16. Rawlinson J, Closkey R, Davis N, Wright T, Windsor R. Stemmed Implants Improve Stability in Augmented Constrained Condylar Knees. Clin Orthop Relat Res 2008;466:2639-43.

17. Scuderi GR, Insall JN, Haas SB, Becker-Fluegel MW, Windsor RE. Inlay autogeneic bone grafting of tibial defects in primary total knee arthroplasty. Clin Orthop Relat Res 1989;248:93-7.

18. Aglietti P, Buzzi R, Scrobe F. Autologous bone grafting for medial tibial defects in total knee arthroplasty. J Arthroplasty 1991;6:287-94.

19. Pierzchała A, Kusz D. The use of structural autograft for massive bone defects in primary total knee replacement. Ortop Traumatol Rehabil 2006;8:195-200.

20. Altchek D, Sculco TP, Rawlins B. Autogenous bone grafting for severe angular deformity in total knee arthroplasty. J Arthroplasty 1989;4:151-5.

21. Keska R, Bira M, Witoński D. Primary total knee arthroplasty with structural autologous bone grafting of medial tibial condyle defect in elderly patients: A preliminary report. Chir Narzadow Ruchu Ortop Pol 2009;74:214-9.

22. Cai X, Wang Y, Wang JF, Zhou YG, Dong JY, Chen JY, et al. Impacted cancellous autograft for reconstructing bone defects of tibial plateau in total knee arthroplasty. Zhonghua Yi Xue Za Zhi 2008;88:2907-11.

23. Lonner JH, Lotke PA, Kim J, Nelson C. Impaction, grafting and wire mesh for uncontained defects in revision knee arthroplasties. Clin Orthop 2002;404:145-51.

J Orthop Sci 2006;6:481-6.